THE EFFECT OF IMPROVED RICE FARMING TECHNIQUES ON MOSQUITO POPULATIONS IN CENTRAL TAIWAN

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INTRODUCTION. During 1967 Japanese encephalitis surveillance, casual observations revealed that the vector populations were lower than had been anticipated. Among speculations as to the cause or causes of the population decline was intensive use of insecticides for rice insect control. Although not directed at mosquitoes, this practice could account for incidental mosquito control.

METHODS AND MATERIALS. A ten-field study area was selected near Taichung, Taiwan on the west central coastal plain. Farming there was quite progressive and insecticides were intensively applied during the rice-growing season. Each day from 10–28 August the following measurements were made in each field: (1) water depth; (2) water temperature; (3) rice growth; (4) water pH; (5) air temperature; (6) relative humidity; (7) number of mosquito larvae based on a selected number of dips; and (8) number of adult mosquitoes in the area based on light-trap catches, pig-biting counts, and 48 sweeps. Information on agricultural practices such as rice-planting dates, insecticide brands, concentration, and application dates was obtained by personal interview with farmers. Followup larval and adult population surveys were conducted 30 and 75 days after the August study was completed.

RESULTS. According to August survey data the adult population was composed of *Culex annulus* (58.9 percent), *C. fatigans* (3.0 percent), *C. tritaeniorhynchus* (1.0 percent), and *Anopheles sinensis* (37.1 percent). The larval population was composed of *Culex annulus* (85.0 percent), *C. tritaeniorhynchus* (5.2 percent), *C. bitaeniorhynchus* (1.0 percent), and *Anopheles sinensis* (8.5 percent).

Air temperature, water temperature, relative humidity, planting dates, and rice

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growth could not be related to mosquito populations according to those data. Air temperature, water temperature, and relative humidity were remarkably constant, possibly owing to a moderate climate in central Taiwan. Planting dates no doubt did affect mosquito populations since at the onset of rice planting there is a rapid and large increase in available breeding habitat for "rice-field" mosquitoes.

Personal interviews with farmers revealed that, ideally, fields were flooded for about 10 days, evacuated for several days, then reflooded. Drying the fields eliminated the larval habitat and therefore had a disastrous effect on larval populations (Figure 1). When the study was initiated on August 10, 1967 all fields were flooded. Fields VI, VII, and VIII were populated at the onset of the study. Larvae were recovered from fields I and X later than expected but these results may indicate error in collecting since the populations were very low in these fields. In many cases, water was detectable within the fields but the level (less than one-quarter inch of water) was not sufficient to favor larval development.

Insecticides were applied about the 1st, 15th, and 25th of August and were never applied alone. Combinations of two or more insecticides and Tuzet, a fungicide, were used at full recommended dose as an all-purpose spray. Most commonly methyl parathion was used with DDT, BHC, dieldrin, or malathion. Due to wind drift and the size of each field, application to one field resulted in incidental application to many other fields in the area. Mean larval population and insecticide application dates are shown in Figure 2. Larval populations began a sharp decline on 12 August, before the mid-August insecticide application. Therefore, it is impossible to evaluate the effect of the insecticides on the larval population. The adult population did decline coincidentally with the first insecticide application date (Figure 3).

Water pH may have had an effect on larval population density. In most cases larvae were encountered in fields with

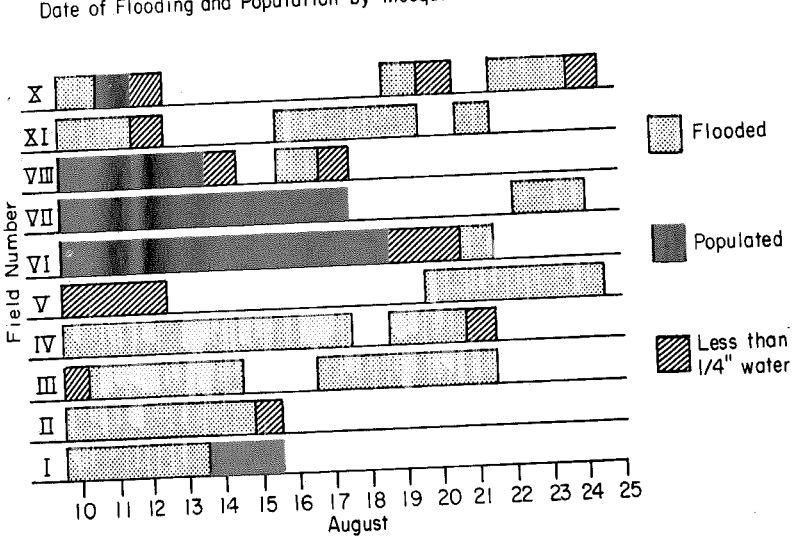

FIGURE 1

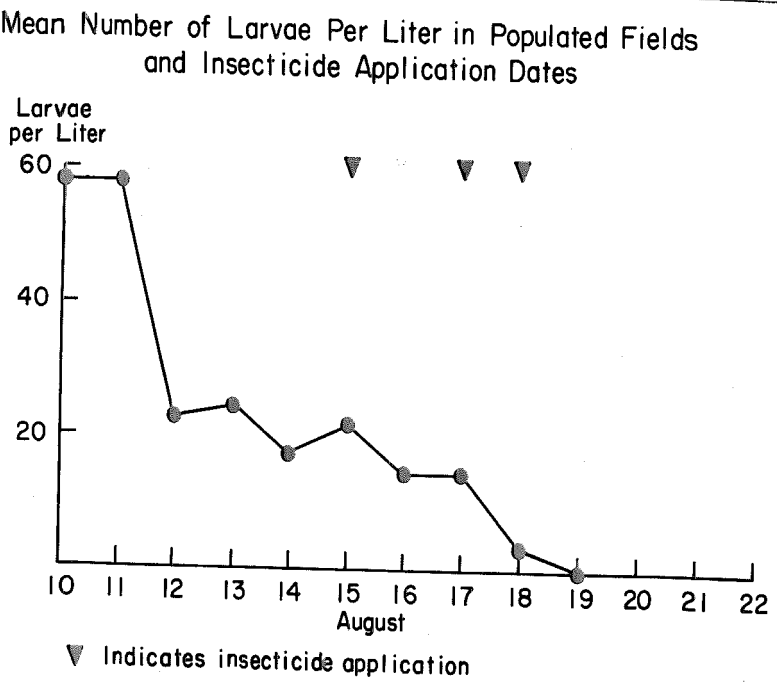

FIGURE 2

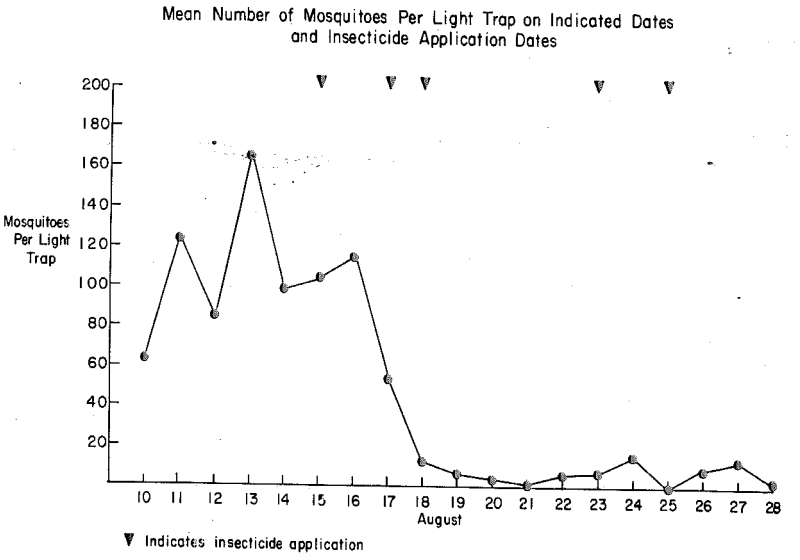

FIGURE 3

TABLE I

Mean pH of Water and Larvae Per Liter in Indicated Fields

Field number	pH	Larvae/L.	pH while populated
I	6.18	12	6.25
II	6.08	—	—
III	6.35	—	—
IV	6.22	—	—
V	6.44	—	—
VI	5.96	16	5.95
VII	5.95	46	5.75
VIII	6.11	24	5.87
IX	6.50	—	—
X	6.00	12	6.00

pH less than 6.0, whereas unpopulated fields all had pH 6.0 and higher. An additional factor was duckweed, which in some fields was so abundant that it apparently inhibited normal oviposition and larval development since no larvae were collected in such fields (Table 1).

Population surveys made 30 and 75 days after completing the August study revealed that the mosquito population was barely detectable. Light traps yielded only one or two adults per night, and pig-biting counts and 48 sweeps of rice fields were negative. At the time of these surveys the rice fields were dry and no suitable larval habitat could be found within a one-mile radius of the study area.

DISCUSSION. The most important factors in mosquito population regulation were rice field flooding-drying schedules and insecticide treatment for rice insect control. These factors could not be analyzed separately since they were in effect at about the same time. Flooding-drying practices were quite catastrophic since they completely eliminated the larval habitat in mid-August. Insecticide application in mid-August appeared to diminish adult populations. With combined effects of drying fields and insecticide application the mosquito populations in intensive, progressive agricultural areas are likely to be quite low during late August.

Insecticide application is of major interest due to the unusual practice of using two or three insecticides in combination. This practice is very conducive to selection of resistant specimens and it is thought that resistance to the common insecticides can be detected.